

# TRANSMISSION POWER CONTROL METHOD AND SYSTEM

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a cellular communications system, and more particularly to a transmission power control technique in a base station.

### 2. Description of Related Art

In code division multiple access (CDMA) systems, soft handover is a well-known technique where a mobile station is simultaneously communicating with multiple base stations, allowing hitless connection switching by making a connection to a new base station while maintaining a connection to an old base station. Soft handover provides diversity, which is a method of using independent fading signals received on several transmission paths all carrying the same message to improve the reliability of the transmission.

In the case of downlink (from base station to mobile station) soft handover, however, multiple base stations simultaneously transmit radio signals to the mobile station, resulting in substantial interferences at adjacent cells. As a technique of suppressing an increase

in interference in the case of downlink soft handover, a downlink transmission power control method has been proposed by Furukawa (Technical Report of Institute of Electronics, Information and Communication Engineers, RCS97-218, February 1998, pp.40, Second chapter). An  
5 outline of the downlink transmission power control method will be described with reference to Figs. 1-4.

It is assumed that a mobile station is communicating with multiple base stations for soft handover.

10 Referring to Fig. 1, a downlink signal from each of the base stations is received at an antenna and is transferred to a down converter 102 through a duplexer 101. The down converter 102 converts the received radio-frequency (rf) signal into a baseband signal and outputs  
15 it to a pilot signal receiver 103. The pilot signal receiver 103 detects a pilot signal from the received baseband signal and measures the intensity or quality thereof. A primary base station decision section 104 compares the intensity/quality measurements of the  
20 received signals to determine a base station transmitting a signal having the maximum intensity/quality as a primary base station to communicate with. A base station selection signal generator 105 generates a base station selection signal from the identification number of the primary base  
25 station. A control signal generator 106 generates control

signals including a transmission power control signal and outputs the control signals to a combiner 107 together with the base station selection signal received from the base station selection signal generator 105. The combiner 107  
5 combines the control signals and the base station selection signal with an uplink information signal to produce a transmission signal. The transmission signal is converted to an rf transmission signal by an up converter 108. The rf transmission signal is further amplified by  
10 an rf amplifier 109 and then transmitted as an uplink signal to the base stations through the duplexer 101. Each of the base stations communicating with the mobile station receives the uplink signal including the base station selection signal from the mobile station.

15 Referring to Fig. 2, at each of the base stations connected to the mobile station, the uplink signal is received at an antenna and is transferred to a down converter 202 through a duplexer 201. The down converter 202 converts the received rf uplink signal to a baseband  
20 signal and outputs it to both a transmission power control signal demodulator 203 and a base station selection signal demodulator 204. The transmission power control signal demodulator 203 demodulates the transmission power control signal from the received baseband signal and outputs it  
25 to a transmission power controller 205. The base station selection signal demodulator 204 demodulates the base

station selection signal from the received baseband signal and outputs it to a primary/non-primary base station mode controller 206.

The transmission power controller 205 produces an  
5 interim controlled transmission power value P1 depending on the transmission power control signal inputted from the transmission power control signal demodulator 203 and outputs the interim controlled transmission power value P1 to the primary/non-primary base station mode controller  
10 206.

The primary/non-primary base station mode controller 206 updates the interim controlled transmission power value P1 depending on the base station selection signal to produce a final controlled transmission power value P2 and output it to a transmission controller 207.  
15 The details of the primary/non-primary base station mode controller 206 will be described later.

The transmission controller 207 receives a downlink transmission signal and performs the output power control  
20 such that the transmission power of the downlink transmission signal is set to the final controlled transmission power value P2. The power-controlled downlink transmission signal is converted into radio frequency by an up converter 208. The rf downlink  
25 transmission signal is amplified by the rf amplifier 209

and then transmitted to the mobile station through the duplexer 201.

Referring to Fig. 3A, a transmission signal between the mobile station and multiple base stations has a frame structure. A frame D-001 consists of  $F_n$  slots to which consecutive numbers from 0 to  $F_n-1$  are assigned, respectively.

As described above, the mobile station transmits the base station selection signal for soft handover to the base stations which it is communicating with. The base station selection signal is composed of a string of bits identifying each of the base stations. Since a plurality of bits are used to form a base station selection signal, redundancy can be provided, resulting in reduced transmission error due to noises and/or fading. Hereinafter, a string of 8 bits identifying each of the base stations is called "a base station selection code word". An example will be described with reference to Fig. 3B.

As shown in Fig. 3B, assuming that a base station selection code word E-002 is "00001111", each part of the code word E-002 is assigned to the dedicated field E-001 of a different uplink slot E-003. In other words, the base station selection code word E-002 is divided into 8 parts (here, each part is one bit) and the respective 8 parts

are transmitted by the dedicated fields E-001 of different slots E-003. Here, a period of base station selection control E-004 is 8 slots, each of which has the dedicated field E-001 for storing a corresponding bit of the 8-bit  
5 base station selection code word E-002. It is possible to accommodate two or more bits of the base station selection code word E-002. The larger the number of bits to be accommodated, the shorter the period of base station selection control E-004.

10 In the cellular system, each base station and each mobile station measure intensities of pilot signals and interference signals received from adjacent cells at regular intervals in order to use them for handover control and call admission control. In the case where a base  
15 station performs the measuring of pilot signals and interference signals, the uplink transmission of each mobile station connected to the base station is temporarily halted to allow the precise measuring of signals from outside cells. Further, there are some cases where the  
20 uplink transmission of a mobile station is halted during communication so as to suppress uplink interference in the case of packet transmission and no-voice transmission.

#### Conventional BS mode update

As described before, the primary/non-primary base  
25 station mode controller 206 in each of the base stations

updates the interim controlled transmission power value P1 depending on the base station selection code word E-002 to produce a final controlled transmission power value P2. The conventional base station mode control is performed  
5 as shown in Fig. 4.

Referring to Fig. 4, the primary/non-primary base station mode controller 206 inputs the base station selection code word E-002 from the base station selection signal demodulator 204 (step S401) and detects the base  
10 station identification number  $BS\_ID_{RSV}$  from the base station selection code word E-002 (step S402). Then, it is determined whether the base station identification number  $BS\_ID_{RSV}$  is identical to the identification number ID of its own (step S403). If the base station  
15 identification number  $BS\_ID_{RSV}$  is identical to the own identification number ID (YES at step S403), then the final controlled transmission power value P2 is set to the interim controlled transmission power value P1 inputted from the transmission power controller 205, that is,  $P2=P1$   
(primary base station mode), (step S404). If the base  
20 station identification number  $BS\_ID_{RSV}$  is not identical to the own identification number ID (NO at step S403), then the final controlled transmission power value P2 is set to a predetermined minimum transmission power value  $P_{MIN}$ ,  
25 that is,  $P2= P_{MIN}$  (non-primary base station mode), (step S405). The predetermined minimum transmission power

value  $P_{\text{MIN}}$  may be 0. The final controlled transmission power value  $P_2$  is output to the transmission controller 207 (step S406).

In this manner, at each of the base stations  
5 communicating with the mobile station, the transmission power selectively switches on and off depending on the base station selection code word E-002 received from the mobile station. Accordingly, multiple base stations are prevented from simultaneously transmitting the same signal  
10 to a single mobile station and thereby interference to adjacent cells is suppressed, resulting in improved communication capacity.

#### 1) Loss of BS selection signal

In the case where the uplink transmission of each  
15 mobile station connected to the base station is temporarily halted as described before, however, the base station selection code word E-002 to be transmitted to the base stations is punctured in part or in entirety as shown in Fig. 3C.

20 More specifically, when the uplink transmission of the mobile station is halted for an uplink transmission puncturing period F-001 in the base station control period E-004, the base station selection code word E-002 is punctured in part and an incomplete code word F-002 is  
25 received at the base stations. Such a partial or entire



loss of the base station selection code word E-002 results in substantially reduced reliability on base station selection control.

## 2) Variation in BS update timing

5           As described before, during the soft handover operation, a plurality of base stations transmit the same signal to a single mobile station. In this case, the transmission timing of the signal is adjusted so that the signals transmitted by the base stations arrive at the  
10 mobile station within an acceptable time deviation. Since propagation distances from the mobile station to the base stations vary from base station to base station, the respective transmission timings of the base stations are different. On the other hand, the base stations also  
15 receive the uplink signal from the mobile station at different timings due to the different propagation distances.

          In the case where the respective transmission timings of the downlink signals and the receiving timings of the  
20 uplink signal including the base station selection signal at the base stations are different as described above, there are cases where actual BS mode update timings of the base stations vary from base station to base station. The details will be described hereinafter.

25           Referring to Fig. 5, a time slot is denoted by

reference symbol G-001 and each transmission signal has a frame structure where 15 slots are numbered from 0 to 14. For simplicity, it is assumed that two base stations 1 and 2 transmit downlink transmission signals G-002 and G-003 to the mobile station with the respective transmission timings (propagation delays: D1 and D2) adjusted so that the downlink transmission signals arrive at the mobile station within an acceptable time deviation.

Accordingly, the mobile station receives the downlink transmission signals G-002 as a downlink reception signal G-004 from the base station 1 and, at the approximately same time, receives the downlink transmission signals G-003 as a downlink reception signal G-005 from the base station 2.

The mobile station transmits an uplink transmission signal G-006 to the base stations 1 and 2 a time period of transmission timing offset  $T_{TR}$  after the downlink reception signals G-004 and G-005 have been received. As described before, the uplink transmission signal G-006 includes the base station selection code word such that respective parts of the base station selection code word are conveyed in the dedicated fields as shown in Fig. 3B.

The base station 2 receives the uplink transmission signal G-006 as an uplink reception signal G-007 with a propagation delay time of D3 and the base station 1 receives

the uplink transmission signal G-006 as an uplink reception signal G-008 with a propagation delay time of D4.

It is assumed that an entire base station selection code word is received when the slot numbered 14 has been received. In this case, the base station 2 starts the primary/non-primary BS mode update operation as shown in Fig. 4 when receiving the last part of the base station selection code word stored in the dedicated field G-020 in the slot numbered 14 of the uplink reception signal G-007. As shown in Fig. 5, the timing of receiving the last part of the base station selection code word falls into the subsequent slot numbered 0. Therefore, the actual primary/non-primary mode update is performed at the further subsequent slot G-017 numbered 1.

Similarly, the base station 1 starts the primary/non-primary BS mode update operation as shown in Fig. 4 when receiving the last part of the base station selection code word stored in the dedicated field G-021 in the slot numbered 14 of the uplink reception signal G-008. As shown in Fig. 5, the timing of receiving the last part of the base station selection code word falls into the next slot but one, that is numbered 1. Therefore, the actual primary/non-primary mode update is performed at the further next slot numbered 2.

In this manner, from the standpoint of the mobile

station, the primary base station update timing of the base station 1 is the slot G-018 numbered 2 and that of the base station 2 is the slot G-019 numbered 1. Since the BS selection code word is transmitted during a period of base station selection control, variations in BS mode update timing may cause loss of a downlink signal. To avoid such a signal loss, the mobile station needs an added circuit for monitoring the BS mode update timing at all times.

#### SUMMARY OF THE INVENTION

10       An object of the present invention is to provide a transmission power control method and system allowing stable and reliable signal transmission.

          Another object of the present invention is to provide a primary base station mode update method ensuring stable and reliable operation in case of loss of a base station selection signal.

          Still another object of the present invention is to provide a primary base station mode update method allowing synchronization among the mode update timings of base stations communicating with a mobile station.

20       According to an aspect of the present invention, a

method for controlling transmission power of a downlink signal from a base station to a mobile station depending on a base station selection signal, wherein the mobile station selects at least one primary base station among a plurality of base stations which are connected to the mobile station for soft handover to produce the base station selection signal designating said at least one primary base station, includes the steps of: at each of the base stations, receiving the base station selection signal from the mobile station; measuring an amount of loss of the base station selection signal; determining whether the amount of loss of the base station selection signal exceeds a threshold; when the amount of loss of the base station selection signal does not exceed the threshold, setting the transmission power of the downlink signal to a selected one of a normally controlled level and a minimum level depending on the base station selection signal; and when the amount of loss of the base station selection signal exceeds the threshold, setting the transmission power of the downlink signal to the normally controlled level.

The amount of loss of the base station selection signal may be a number of erroneously received bits in the base station selection signal. The amount of loss of the base station selection signal may be a ratio of a punctured length to a length of the base station selection signal. The threshold may vary depending on a length of the base

station selection signal. The threshold may vary depending on the length of the base station selection signal.

According to another aspect of the present invention,  
5 a method for controlling transmission power of a downlink signal which is transmitted in frames from a base station to a mobile station depending on a base station selection signal, wherein the mobile station selects at least one primary base station among a plurality of base stations  
10 which are connected to the mobile station for soft handover to produce the base station selection signal designating said at least one primary base station, wherein an uplink signal including the base station selection signal is transmitted in frames to the base stations, the method  
15 includes the steps of: at each of the base stations, a) receiving the uplink signal including the base station selection signal from the mobile station; b) determining a transmission power update timing so that the downlink signal received at the mobile station changes in  
20 transmission power at a predetermined timing synchronized with that of other base stations; and c) when reaching the transmission power update timing, setting the transmission power of the downlink signal to a selected one of a normally controlled level and a minimum level depending on the base  
25 station selection signal.

Each frame of the uplink signal and the downlink signal may be composed of a plurality of time slots which are numbered consecutively, wherein the transmission power update timing in each of the base stations is represented  
5 by a number of same time slot.

The time slot number indicating the transmission power update timing may be determined by delaying a receiving time of the base station selection signal by an amount of time determined so that the downlink signal  
10 received at the mobile station changes in transmission power at same timing.

The time slot number indicating the transmission power update timing is preferably determined by

$$(j + T_{os}) \bmod F_n,$$

15 where  $j$  is number of a time slot indicating a last portion of the base station selection signal,  $T_{os}$  is waiting time for transmission power update,  $F_n$  is number of slots included in one frame, and  $\bmod$  is an operator whose result is the remainder of a division operation.

20 The waiting time  $T_{os}$  may vary depending on a propagation delay between the base station and the mobile station. The waiting time  $T_{os}$  may vary depending on the time slot number  $j$ .

As described above, according to the present

invention, when the amount of loss of a base station selection signal received from a mobile station exceeds a predetermined level, the base station mode does not reduce the transmission power of the downlink signal  
5 regardless of whether the base station selection signal instructs the base station itself to be the primary base station or not. Therefore, base station selection error due to a low-reliable base station selection signal can be avoided. Especially, in the case where a base station  
10 is designated as the primary base station, it is avoided that the base station erroneously reduces or switches off the transmission power.

Further, since the update timings of the base stations are in synchronization with each other in the  
15 downlink signal received at the mobile station, loss of a downlink signal caused by loss of synchronism can be avoided without the need of an added circuit for monitoring the mode update timing at the mobile station.

#### BRIEF DESCRIPTION OF DRAWINGS

20 Fig. 1 is a schematic diagram showing a configuration of a mobile station in a mobile communications system;



Fig. 2 is a schematic diagram showing a configuration of a base station in the mobile communications system;

Fig. 3A is a diagram showing a frame format of an uplink signal transmitted from a mobile station to a base  
5 station;

Fig. 3B is a diagram showing the frame format of an uplink signal for explaining a method of transmitting a base-station selection signal;

Fig. 3C is a diagram showing the frame format of an  
10 uplink signal for explaining an uplink transmission stop period;

Fig. 4 is a flow chart showing a conventional method of updating the primary/non-primary base station mode;

Fig. 5 is a time chart showing the base-station mode  
15 update timing in the conventional method;

Fig. 6 is a flow chart showing a method of updating

the primary/non-primary base station mode according to a first embodiment of the present invention;

Fig. 7 is a flow chart showing a method of updating the primary/non-primary base station mode according to a  
5 second embodiment of the present invention;

Fig. 8 is a time chart showing the base-station mode update timing according to the second embodiment; and

Fig. 9 is a flow chart showing a method of updating the primary/non-primary base station mode according to a  
10 third embodiment of the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention will be described in detail with reference to Figs. 6-9. Each of the embodiments will be described as a control  
15 operation of the primary/non-primary base station mode controller 206 at a base station, which may be implemented by a control program running on a program-controlled

processor in the primary/non-primary base station mode controller 206.

As described before, the primary/non-primary base station mode controller 206 in each of the base stations  
5 updates the interim controlled transmission power value P1 depending on the base station selection code word E-002 to produce a final controlled transmission power value P2.

#### FIRST EMBODIMENT

Referring to Fig. 6, a first embodiment of the present  
10 invention controls the transmission power taking into consideration the amount of loss of a base station selection signal or code word.

More specifically, the primary/non-primary base station mode controller 206 inputs the base station  
15 selection code word from the base station selection signal demodulator 204 (step S601) and measures the amount of loss of the base station selection code word (step S602). The amount of loss of the base station selection code word may be the number of punctured bits as shown in Fig. 3C or the  
20 ratio of the number of punctured bits to the number of all bits of the base station selection code word. Hereafter, the amount of loss of the base station selection code word is denoted by  $L_{CW}$ .

Subsequently, it is determined whether the amount  
25 of loss of the base station selection code word,  $L_{CW}$ , is

greater than a threshold  $L_{TH}$  (step S603). The threshold  $L_{TH}$  may vary depending on the length of the base station selection code word.

If  $L_{CW} > L_{TH}$  (YES at step S603), then it is determined  
5 that the demodulated base station selection code word is  
not sufficiently reliable and the final controlled  
transmission power value  $P2$  is set to the interim  
controlled transmission power value  $P1$  inputted from the  
transmission power controller 205, that is,  $P2=P1$  (primary  
10 base station mode), (step S604). In other words, the  
transmission power is not suppressed regardless of whether  
the base station itself is the primary base station or not.

If  $L_{CW}$  is equal to or lower than  $L_{TH}$  (NO at step S603),  
then the base station identification number  $BS\_ID_{RSV}$  is  
15 detected from the base station selection code word (step  
S605). Then, it is determined whether the base station  
identification number  $BS\_ID_{RSV}$  is identical to the  
identification number  $ID$  of its own (step S606).

If the base station identification number  $BS\_ID_{RSV}$  is  
20 identical to the own identification number  $ID$  (YES at step  
S606), then the final controlled transmission power value  
 $P2$  is set to the interim controlled transmission power  
value  $P1$ , that is,  $P2=P1$  (primary base station mode), (step  
S604). If the base station identification number  $BS\_ID_{RSV}$   
25 is not identical to the own identification number  $ID$  (NO

at step S606), then the final controlled transmission power value P2 is set to a predetermined minimum transmission power value  $P_{\text{MIN}}$ , that is,  $P2 = P_{\text{MIN}}$  (non-primary base station mode), (step S607). The predetermined minimum  
5 transmission power value  $P_{\text{MIN}}$  may be 0. The final controlled transmission power value P2 is output to the transmission controller 207 (step S608).

Alternatively, if the base station identification number  $\text{BS\_ID}_{\text{RSV}}$  is not identical to the own identification  
10 number ID (NO at step S606), it may be further determined whether the reception quality of the base station selection code word satisfies a predetermined level. If the reception quality does not satisfy the predetermined level, then it is determined that the demodulated base station  
15 selection code word is not sufficiently reliable, and the final controlled transmission power value P2 may be set to the interim controlled transmission power value P1 (step S604).

As described above, in the case where the amount of  
20 loss of the base station selection code word is greater than the threshold, in other words, where the demodulated base station selection code word is not sufficiently reliable, the transmission power is not suppressed regardless of whether the base station itself is designated  
25 as the primary base station or not.

## SECOND EMBODIMENT

Referring to Fig. 7, a second embodiment of the present invention controls the BS mode update timing so that synchronization among the primary/non-primary mode  
5 update timings of base stations is achieved.

More specifically, the primary/non-primary base station mode controller 206 inputs the base station selection code word from the base station selection signal demodulator 204 (step S701) and detects the base station  
10 identification number  $BS\_ID_{RSV}$  from the base station selection code word E-002 (step S702). Then, variable  $i$  is set to the number of a current slot and variable  $j$  is set to the number of a slot conveying the last part of the base station selection code word (step S703). Thereafter,  
15 it is determined whether the following equation (1) is satisfied (step S704):

$$i = (j + Tos) \bmod Fn \quad (1),$$

where  $Tos$  is waiting time for mode update,  $Fn$  is the number of slots included in one frame, and  $X \bmod Y$  is an operator  
20 whose result is the remainder of a division operation ( $X/Y$ ). In other words, the base station mode updating operation is not performed until the current slot reaches a slot numbered  $(j + Tos) \bmod Fn$ .

When the equation (1) is satisfied (YES at step S704),  
25 it is determined whether the base station identification

number  $BS\_ID_{RSV}$  is identical to the identification number ID of its own (step S705). If the base station identification number  $BS\_ID_{RSV}$  is identical to the own identification number ID (YES at step S705), then the final controlled transmission power value P2 is set to the interim controlled transmission power value P1 inputted from the transmission power controller 205, that is,  $P2=P1$  (primary base station mode), (step S706). If the base station identification number  $BS\_ID_{RSV}$  is not identical to the own identification number ID (NO at step S705), then the final controlled transmission power value P2 is set to a predetermined minimum transmission power value  $P_{MIN}$ , that is,  $P2= P_{MIN}$  (non-primary base station mode), (step S707). The predetermined minimum transmission power value  $P_{MIN}$  may be 0. The final controlled transmission power value P2 is output to the transmission controller 207 (step S708).

Alternatively, if the base station identification number  $BS\_ID_{RSV}$  is not identical to the own identification number ID (NO at step S705), it may be further determined whether the reception quality of the base station selection code word satisfies a predetermined level. If the reception quality does not satisfy the predetermined level, then it is determined that the demodulated base station selection code word is not sufficiently reliable, and the final controlled transmission power value P2 may be set

to the interim controlled transmission power value P1 (step S706).

Referring to Fig. 8, a time slot is denoted by reference symbol J-001 and each transmission signal has a frame structure where  $F_n$  ( $=15$ ) slots are numbered from 0 to 14. For simplicity, it is assumed that two base stations 1 and 2 transmit downlink transmission signals J-002 and J-003 to the mobile station with the respective transmission timings (propagation delays:  $D_1$  and  $D_2$ ) adjusted so that the downlink transmission signals arrive at the mobile station within an acceptable time deviation.

Accordingly, the mobile station receives the downlink transmission signals J-002 as a downlink reception signal J-004 from the base station 1 and, at the approximately same time, receives the downlink transmission signals J-003 as a downlink reception signal J-005 from the base station 2.

The mobile station transmits an uplink transmission signal J-006 to the base stations 1 and 2 a time period of transmission timing offset  $T_{TR}$  after the downlink reception signals J-004 and J-005 have been received. As described before, the uplink transmission signal J-006 includes the base station selection code word such that respective parts of the base station selection code word are conveyed in the dedicated fields as shown in Fig. 3B.



The base station 2 receives the uplink transmission signal J-006 as an uplink reception signal J-007 with a propagation delay time of D3 and the base station 1 receives the uplink transmission signal J-006 as an uplink reception  
5 signal J-008 with a propagation delay time of D4.

It is assumed that an entire base station selection code word is received when the slot numbered 14 has been received, that is,  $j = 14$ , and the mode update waiting time  $Tos$  is set to 3,  $F_n = 15$ . In this case,  $(j + Tos) \bmod F_n$   
10  $= 2$ . Therefore, the base station 1 performs the actual mode update at the slot J-017 numbered 2. Similarly, the base station 1 also performs the actual mode update at the slot J-017 numbered 2.

In this manner, from the standpoint of the mobile  
15 station, the primary base station update timing of the base station 1 is in synchronization with that of the base station 2.

It is preferable that the waiting time  $Tos$  is as short as possible to achieve high-speed mode switching. Since  
20 the propagation delay and processing delay in a base station may vary, it is possible to make the waiting time  $Tos$  variable during communication.

Further, the waiting time  $Tos$  may be varied depending on the number  $j$  of the slot conveying the last part of the  
25 base station selection code word. In this case, the

primary base station mode update timing at the mobile station can be set to a desired timing.

### THIRD EMBODIMENT

Referring to Fig. 9, a third embodiment of the present invention is a combination of the first and second embodiments. Steps S901-S905 are the same as the steps S701-S705 of Fig. 7, respectively. If the base station identification number  $BS\_ID_{RSV}$  is identical to the own identification number ID (YES at step S905), then it is determined whether the amount of loss of the base station selection code word,  $L_{CW}$ , is greater than a threshold  $L_{TH}$  (step S906).

If  $L_{CW} > L_{TH}$  (YES at step S906), then it is determined that the demodulated base station selection code word is not sufficiently reliable and the final controlled transmission power value P2 is set to the interim controlled transmission power value P1 inputted from the transmission power controller 205, that is,  $P2=P1$  (primary base station mode), (step S604). In other words, the transmission power is not suppressed regardless of whether the base station itself is the primary base station or not.

If  $L_{CW}$  is equal to or lower than  $L_{TH}$  (NO at step S906), then the final controlled transmission power value P2 is set to a predetermined minimum transmission power value  $P_{MIN}$ , that is,  $P2= P_{MIN}$  (non-primary base station mode), (step

S908). The final controlled transmission power value P2 is output to the transmission controller 207 (step S909).

Alternatively, if the base station identification number  $BS\_ID_{RSV}$  is not identical to the own identification number ID (NO at step S905), it may be further determined whether the reception quality of the base station selection code word satisfies a predetermined level. If the reception quality does not satisfy the predetermined level, then it is determined that the demodulated base station selection code word is not sufficiently reliable, and the final controlled transmission power value P2 may be set to the interim controlled transmission power value P1 (step S907).

As described above, according to the present invention, when the amount of loss of a base station selection signal received from a mobile station exceeds a predetermined level due to an uplink puncturing operation of the mobile station, the base station mode is set to the primary mode regardless of whether the base station selection signal instructs the base station itself to be the primary base station or not. Therefore, such a decision error that the base station is erroneously set to the non-primary base station mode due to reception error can be effectively eliminated, resulting in stable and reliable quality of a downlink signal from the base station

to the mobile station.

Further, since the update timings of the base stations are in synchronization with each other in the downlink signal received at the mobile station, loss of  
5 a downlink signal caused by loss of synchronism can be avoided without the need of an added circuit for monitoring the mode update timing at the mobile station.